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Procedia Economics and Finance 1 (2012) 286 – 295

Procedia Economics and Finance

www.elsevier.com/locate/procedia

International Conference On Applied Economics (ICOAE) 2012

Interest rate shocks, Central Bank's Credibility and Inflation Targeting Regime: simulations in a Dynamic Stochastic General Equilibrium Model

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Abstract

This article analyzes the Central Bank's endogenous and nonlinear credibility, under shocks and inflation targeting regime. Monetary policy regimes are compared, which are different in terms of endogenous credibility levels and their nonlinear sensibility to the observed economic deviations. It shows that the higher the credibility level, the lower its sensibility to the observed deviations and, as a consequence, the higher the flexibility power for the central bank to stimulate the economy without expressive unstable results. This proposition is verified through a stochastic autoregressive dynamic model and a small numeric simulation.

Keywords: Central Bank; Credibility; Inflation Target.

2212-5671 © 2012 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of the Organising Committee of ICOAE 2012
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1. Introduction

The Central Bank's credibility is an important feature in the implementation of monetary policy strategies. The ability a Central Bank has in order to control inflation dynamics, with lower social costs through the time, depends basically on its power in managing public's inflationary expectations. The higher the Central Bank's credibility level, the lower the expected inflation rate sensibility to the observed inflation deviations; and the higher the weight of the announced inflation target in the public's expectations. It gives power to the Central Bank to implement counter-cyclical monetary policies with lower unstable results for the economy.

Thus, modeling and estimating the Central Bank's credibility dynamics is one of the main topics in the monetary policy research, because it identifies the ways by which monetary authorities can improve its credibility gains (and losses) and the effects of it on the economic and policy dynamics.

In line with Argov et al. (2007), this work implements a small-scale structural macro model that does not present explicit microfoundations, but resembles New-Keynesian models, such as in Ball (1999), Svensson (1997) and Clarida, Galí & Gertler (1999), among others, thereby becoming useful in analyzing monetary policy implementation and dynamic macro responses from different kinds of shocks, specifically the interest rate shocks in this paper. The key difference between the current model and standard New-Keynesian models is in the Central Bank's endogenous and nonlinear credibility, such as in Lalonde (2005), which will be proposed.

As it will be shown by the results of the numeric simulations, interest rate shocks cause lower output variability when the credibility dynamics is conceived as an endogenous and nonlinear process, in comparison with the results under constant or exogenous credibility degrees. Moreover, the study verifies that the initial credibility level is an important factor in determining the relevant variables' dynamics. That is, the higher the Central Bank's initial credibility level, the lower the output variability as a consequence of shocks, even if the credibility dynamics is modeled as an endogenous and nonlinear variable. This result may explain why some Central Banks are faced by higher economic instability through the time, in relation to others, even when the Central Banks sample is under similar monetary policy regimes and economic shocks. So, in Central Bank's performance the history and the credibility gains process matter.

2. Theoretical approach: the credibility *versus* flexibility dilemma

Taking the real interest rate as the main policy instrument, the central bank's credibility is associated with the public's perception of a desirable and coherent direction and velocity of the instrument rate path in the face of the central bank's target. In this case, two things are essential while the economic agents are making their evaluation about the central bank and about its monetary policy credibility: the *policy target* and the observed shifts in the *policy instrument*, as it is the relation between these two variables that determines the credibility degree and the effectiveness of the monetary policy[b].

A useful estimator in evaluating monetary policy would be the real interest rate trajectory in relation to the *natural interest rate*. However, it is generally accepted the public's and the central bank's uncertainty on the natural interest rate level (Galí & Gertler, 2007), so that the monetary policy efficiency and credibility should

[b] This concept of credibility is in the same way followed by Argov et al. (2007), among others, that is, credibility as the public's assessment of the central bank's ability to achieve the target.

be estimated through other indicators, such as inflation deviations and output gaps around their target and normal levels. Hence, if the public identifies deviations of the inflation rate from the inflation target and of the output level around the potential output level, there are signals in the sense that the real interest rate path diverges in relation to the natural rate trend. Obviously, it is assumed that the potential output is an observable variable or that it can be estimated by statistical filters, such as the Hodrick-Prescott filter, commonly applied in the empirical studies.

In a monetary policy regime in which inflation control is the main (and the announced) central bank's objective, the public evaluates the bank's commitment and reputation by means of an analysis of the effects of interest rate shifts on the observed output levels, inflation rates, and on the expected inflation rates. Interest rate shifts that demonstrate to be inadequate with regard to their direction and/or velocity, in the face of the inflation control objective and the structural model, are also evaluated as wrong shifts by the public, and thereby decreasing the central bank' reputation (Sicsú, 2001). And under lower reputation, the central bank implements a monetary policy without or with lower credibility, as a consequence of the observed policy errors in the past periods.

What is the main problem of a policy with lower or without credibility? Under lack of credibility, the agents' expectations do not converge to the central bank's goal or announcement. In such a case, there is a kind of a conflict between the central bank and the public, given that the interest rate adjustments do not achieve desirable control of the public's expectations, and so making the target much more expensive to be reached (Ball, 2002). Specifically in the case of the monetary policy, the lower the credibility, the higher the expected inflation, and thereby the higher the output and employment sacrifice ratio if the central bank is looking for a disinflation (Clarida, Galí & Gertler, 1999). In other words, lower credibility degrees are followed by an expected inflation that is more sensible to the past inflation deviations and less sensible to the central bank's announcements. In such a case, the inflation control has to be made by raising strongly real interest rate and by pushing down the production levels, as a consequence of the inconsistence between the public's forecasts and the central bank's intentions.

Propositon 1: *Central banks with lower (higher) credibility degrees are constrained (improved) by inflationary dynamics which is more (less) sensible to the past inflation levels, that is, in such a case there is more (less) inertia in the inflationary process.*

The central bank' credibility depends on its commitment to the announced target, given the assumption according to which this target is compatible with the economic structure (the structural model). This commitment, in its turn, is perceived by the public if the target is attained periodically and/or the instrument policy adjustments are regarded as consistent in the face of policy goal.

Hence, in order to gain credibility, some degree of rigidity or inflexibility for the monetary policy is necessary, at least initially while the last one is seen as non-credible (King, 1996). As long as the credibility is not consolidated, the central bank should avoid deviations from its target, at least in order to decrease the necessary time in building reputation and credibility. Under low credibility, the public translates small deviations as a lack of commitment, or as wrong target announcements, or even as inadequate adjustments of interest rates. In such a context, the expected inflation diverges from the inflation target, making the last one more difficult to be attained, even if the central bank really has implicit commitment to the announced goal.

Obviously, the deviations from the target can be justified under specific situations, given their social benefit/cost ratio. However, the specific situation should be transitory. Hence, although some deviations are justifiable, they should be constrained through the time, if the monetary authority looks for maximizing the credibility. As it will be shown formally, the higher the credibility, the lower the weight on the past inflation rates in the expected inflationary process (there will be more weight on the announced target), and the lower the sensibility of the credibility level to the observed deviations. It means that the credibility process is endogenous to the past inflation outcomes and has a kind of nonlinear sensibility to the observed economic

deviations, in line with the works of Argov et al. (2007) and Alich et al. (2009). In such an economy, the central bank receives power to be more flexible in managing interest rates, given that new divergences between the inflation rate and the inflation target do not have significant impacts on the inflation expectations, and the credibility level is not affected as a consequence of the lower sensibility of the last one to the observed inflation deviations.

The flexibility is the yield a central bank earns by consolidating credibility in higher levels. However, while the monetary authority has low credibility degree, the flexibility is not so reasonable, given that any small inflation deviation and output gap can create expected inflation deviations, inflation inertia and new credibility losses[c], as a consequence of the higher sensibility of the credibility to the observed deviations. The credibility versus flexibility dilemma could be also illustrated by means of the *trade-off* between inflation and output variances, in the case of supply shocks. There is an exchange through time between inflation variability and output variability, when central banks are setting off inflationary processes that have been originated by supply shocks (for example, an increase in commodity and energy prices) (Svensson, 1997; Ball, 1999). In such a context, pushing down inflation deviation imposes necessarily higher output gaps.

If monetary authority raises real interest rate in order to decrease inflation, output will present reduction, by staying below its potential level. Hence, under supply shocks, it is commonly accepted some degree of inflation accommodation as a means of avoiding output losses (Svensson, 1997; Clarida, Galí & Gertler, 1999). However, with low credibility levels, inflation accommodation can have significant impacts on the expected inflation, on the inflationary dynamics through inertia components and on the credibility levels.

Proposition 2: *When central banks have low (high) credibility degree, its power to accommodate supply shocks, and maintain employment levels, is constrained (improved).*

On the other hand, the higher the central bank's credibility levels, the higher the flexibility power to accommodate inflation and to concern with real variables under supply shocks. In the same way, central banks with high credibility degree have power to adjust interest rates for stimulating economic activity, without generating economic instability, as expected inflation is strongly anchored on inflation target and credibility degree is not so sensible to observed gaps[d]. Therefore, taking into account this endogeneity and nonlinear nature of the central bank's credibility, what should we expect in terms of real variables trajectories when different qualities (e.g. different credibility degrees) of monetary policy regimes are facing interest rate shocks?

3. The endogenous and nonlinear credibility degree model

A credibility index and its endogenous and nonlinear dynamics

In line with Argov et al. (2007), the following small-scale structural macro model does not present explicit microfoundations, but it resembles New-Keynesian models, such as in Ball (1999), Svensson (1997) and Clarida, Galí & Gertler (1999), thereby becoming useful in analyzing monetary policy implementation and dynamic macro responses from different kind of shocks, specifically interest rate shocks in this paper. The key difference between the following model and the standard New-Keynesian models is in the central bank's endogenous and nonlinear credibility, which will be proposed.

Let the credibility degree be expressed by:

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[c] In other words, lack of credibility raises the weight of past observed inflation (backward component) on the expected inflation and the output-inflation trade-off (Argov et al., 2007).

[d] The conventional literature on credibility sees a positive correlation between credibility levels and the weight on the announced target in the expected inflation function (See Argov et al., 2007; Lalonde, 2005).

$$(1)\ C_t = \sum_{i=0}^{n} a^i \left| 1 / r_{t-1-i} \right| + u_t$$

Expression (1) says that *credibility degree* (C), under a general specification, is function of *lagged adjustments of interest rates* (R) vis-à-vis *natural interest rate* (R^T)[e], letting be $r_t = R_t - R^T$, u_t a shock (random control error) with zero mean and constant variance, and *n* the relevant number of lags. Let natural rate be what make possible output equaling to potential output and inflation equaling to inflation target. In general, natural rate is understood as a real interest rate level that allows a non inflationary output growth. By (1), lower the real interest rate deviation from natural rate, higher the credibility through time.

However, as public does not know precisely at what level the natural rate is, it is necessary to take into account relevant observable variables to infer about the monetary policy commitment. So, let *credibility degree* be*:*

$$(2)\ C_t = \sum_{i=0}^{n} a^i \left| 1 / \pi_{t-1-i} \right| + \sum_{i=0}^{n} b^i \left| 1 / y_{t-1-i} \right| + u_t$$

By (2), under a general specification, the lower inflation and output deviations from their targets, the higher the credibility degree attained by the central bank. Now, in a particular specification and for analytical reason, so that credibility degree is ranging from 0 to 1, let the credibility determination process be:

(3) $C_t = 1$, if π_{t-1} is equal to zero, which is regarded as a special case, and:

(4) $C_t = \delta C_{t-1} + (1 - \delta) \left[\dfrac{\left| \alpha \left| \pi_{t-1} \right| - 1 \right|}{\alpha \left| \pi_{t-1} \right| + 1} \right]$, if π_{t-1} is different from zero[f], which is regarded as a general case.

Equation (4) makes credibility level approximating to 0, as inflation deviations increase in t-1 period, and approximating to 1 as deviations decrease in t-1. Moreover, credibility level depends on its past value (C_{t-1}) – an auto-regressive component –, given the positive inertial coefficient δ. Now, let the *expected inflation deviation* be built by a process such as:

$$(5)\ E_t[\pi_{t+1}] = (1 - C_{t-1})(\pi_{t-1})$$

By (5), if credibility in t-1 period is maximum ($C_{t-1} = 1$), expected inflation deviation for t+1 period equals to zero, even if a positive or negative inflation deviation really happened in t-1 period. It means that, under $C_{t-1} = 1$, inflation expectation is fully anchored on the inflation target. On the other hand, if $C_{t-1} < 1$ expected inflation deviation is partially or integrally (for $C_{t-1} = 0$) dependent on inflation deviation in t-1.

In turn, someone can ask: does credibility degree have linear sensibility to inflation deviations? In other words, is α (in equation 4) fixed as C varies through time? If answer is yes, it means that, for all credibility

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[e] That is, real interest rate is *Granger cause* of credibility.

[f] Equation (4) for simplicity does not consider the random control error. Moreover, equation 4 is more convenient, algebraically, under non explosive shocks.

levels, central bank's credibility is affected in the same way by new inflation deviations. But, like suggested by King (1996), it is easy to think of a nonlinear relation between observable gaps and credibility variation, depending on the credibility level under consideration.

Let's assume that exist a *critical credibility level*, below which credibility degree becomes more sensible to observable deviations, that is, α is increased. This nonlinearity in α parameter contributes to impose a penalty on central banks with low credibility levels, augmenting the risks of new credibility losses; at the same time, the nonlinearity contributes to reward central banks with higher credibility levels, giving them more power to implement deliberated monetary policies.

Let's consider α_1 the parameter value that is verified in period t if $C_{t-1} \geq C^T$ (a critical level); in turn, consider α_2 the parameter value that is verified in period t if $C_{t-1} < C^T$; and assume necessarily $\alpha_1 < \alpha_2$. Formally in Table 1 below:

Table 1 - Nonlinearity of the credibility level sensibility to observed gaps

If $C_{t-1} \geq C^T \rightarrow$ system has α_1 in period t.	If $C_{t-1} < C^T \rightarrow$ system has α_2 in period t.	Let additionally be $\alpha_1 < \alpha_2$.

Source: Own elaboration.

Hence, when the central bank presents high credibility in the previous period ($C_{t-1} \geq C^T$), equation 4 in period t works through α_1 value; it means credibility degree shows lower sensibility to observed gaps; but if central bank presents low credibility in the previous period ($C_{t-1} < C^T$), equation 4 in period t works through α_2 value, credibility degree becoming more sensible to observed economic deviations.

Economic activity, inflation rate and monetary policy rule

The economic activity deviation is determined by an IS dynamic equation, such as:

$$(6)\ y_t = m(y_{t-1}) - n(r_{t-1}) + \eta_t$$

The output gap (y_t) depends on the lagged output gap (y_{t-1}) and the lagged interest rate deviation (r_{t-1}); there is a demand shock, η, a stochastic process with zero mean and fixed variance (*white noise process*); all the parameters, *m* and *n*, are positives. Additionally, let us consider the output gap as a deviation of the effective output (Y_t) in relation to potential output (Y^p): $y_t = Y_t - Y_t^{pg}$.

In its turn, the inflation rate process is given through a Phillips dynamic equation:

$$(7)\ \pi_t = E_t[\pi_{t+1}] + \varpi(y_{t-1}) + g_t$$

Equation (7) establishes that inflation rate deviation (π_t) is determined by inflation expectation for t+1 period ($E_t[\pi_{t+1}]$), by the lagged output gap (y_{t-1}) and by the supply shock (g_t), defined as a stochastic process with zero mean and fixed variance (*white noise process*); the parameters, τ and ϖ, are positive. Here, inflation deviation means a divergence between inflation rate (Π_t) and inflation target (Π^n). Hence, $\pi_t = \Pi_t - \Pi^n$.

[g] In the same way, let r_{t-1} be the deviation of the real interest rate (R_{t-1}) *vis-à-vis* the natural interest rate (R^n).

Substituting (4) and (5) in (7):

$$(8)\ \pi_t = \{1 - [\delta C_{t-1} + (1 - \delta)\left(\frac{|\alpha|\pi_{t-1}| - 1|}{\alpha|\pi_{t-1}| + 1}\right)]\}(\pi_{t-1}) + \varpi(y_{t-1}) + g_t$$

In equation 8 it is possible to verify the inverse correlation between the credibility degree in past period and the current inflation deviation. Finally, the monetary policy rule is described by:

$$(9)\ r_t = (1 - \rho)(z_1 \pi_t + z_2 y_t) + (\rho)r_{t-1} + \psi_t$$

Hence, the current real interest rate deviation depends on inflation and output gaps and on the past interest rate deviations, given z_1 and z_2 are positive parameters, ρ is the inertial coefficient of the monetary policy and ψ_t is the monetary policy's innovation component or shock, with zero mean and constant variance.

4. Methodology and results

4.1. Methodology

The methodology of simulating follows broadly Ball's (1999) article and Walsh's (2003) work. As said by the latter, "*since we can vary the parameters of our theoretical models in ways we cannot vary the characteristics of real economies, simulation methods allow us to answer a variety of 'what if' questions*" (Walsh, 2003, p. 67).

The simulation strategy has the following step-by-step:

i) From an expansionary monetary policy shock, it is simulated how the output gap would behave if credibility degree was constant through the time, under different credibility degree values (0.9; 0.5; 0.1), that is, in such cases, C is a constant in equation 5;

ii) From an expansionary monetary policy shock, it is simulated how the output gap behaves when the credibility degree varies with the inflation deviations, starting from 0.1 ($C_0 = 0.1$), 0.5 ($C_0 = 0.5$) and 0.9 ($C_0 = 0.9$), and this sensibility also changes according to the modifications in the credibility degree, that is, all the equations hold integrally. The Table 2 below presents the parameter values used in the simulations:

Table 2 – Parameter values for the simulations

δ	α*	M	z_1	N	ϖ	ρ	z_2
0.8	0.2 or 0.9	0.8	0.3	0.4	0.6	0.5	0.6

(*) $\alpha = 0.2$, if $C_{t-1} \geq 0.5$; and $\alpha = 0.9$, if $C_{t-1} < 0.5$. Source: Own elaboration.

4.2. Results

Initially, the **Graph 1** shows how the output gap behaves from an expansionary monetary policy shock, under three different regimes, which impose constant credibility degrees for the central bank. The regime with the credibility degree equal to 0.1 is the more unstable, in comparison with both the regimes that present credibility degrees equal to 0.5 and to 0.9. Therefore, the higher the credibility degree, the higher the flexibility for the central bank to stimulate the economy, as interest rate fluctuations do not cause significant economic instability. In such cases, however, the observed gaps do not imply changes in the credibility degree

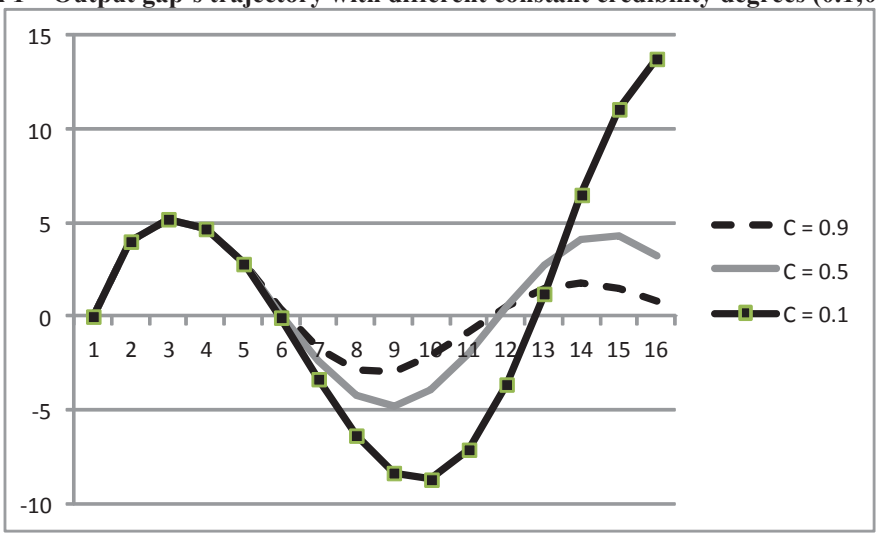
along the time, and, as a consequence, the inflation expectations have constant sensibility to the past inflation deviations. Endogeneity and nonlinearity do not exist in the credibility determination process.

On the other hand, what would occur with the output gap dynamics if those endogeneity and nonlinearity were verified? The **Graph 2** presents the different output dynamics under: i) a regime in which the credibility degree is endogenous and its sensibility to the observed gaps is nonlinear (*Endogenous and Nonlinear Regime* – ENR 0.1), thereby initiating from $C_0 = 0.1$; ii) a regime in which the credibility degree is endogenous and its sensibility to the observed gaps is nonlinear (ENR 0.5), thereby initiating from $C_0 = 0.5$; iii) a regime in which the credibility degree is endogenous and its sensibility to the observed gaps is nonlinear (ENR 0.9), thereby initiating from $C_0 = 0.9$.

As it was simulated, all the ENRs are subjected to the economic fluctuations as an effect of monetary policy shocks, but the ENR (0.9) – i.e. the endogenous and nonlinear regime that has the higher initial credibility degree – has the lower volatility in the output gap trajectory.

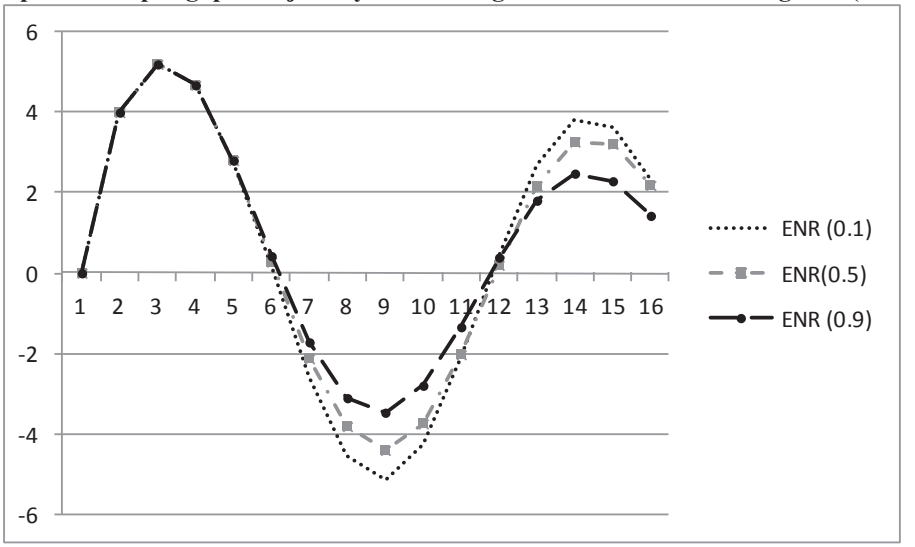
In its turn, the ENR (0.1) – i.e. the endogenous and nonlinear regime that has the lower initial credibility degree – has the higher volatility in the output deviations along the time. Hence, the central bank under ENR (0.9) has more flexibility to impose monetary policy shocks on the economy, with lower costs, basically because the output and inflation deviations do not create expressive non-alignment in the inflation expectations, which are initially more anchored in the inflation target than in the cases of ENR (0.5) and ENR (0.1). Therefore, the ENR (0.9) makes the credibility degree less sensible to the past inflation deviations than what occurs under the ENR (0.5) and the ENR (0.1).

Graph 1 – Output gap's trajectory with different constant credibility degrees (0.1;0.5;0.9)



Source: own elaboration.

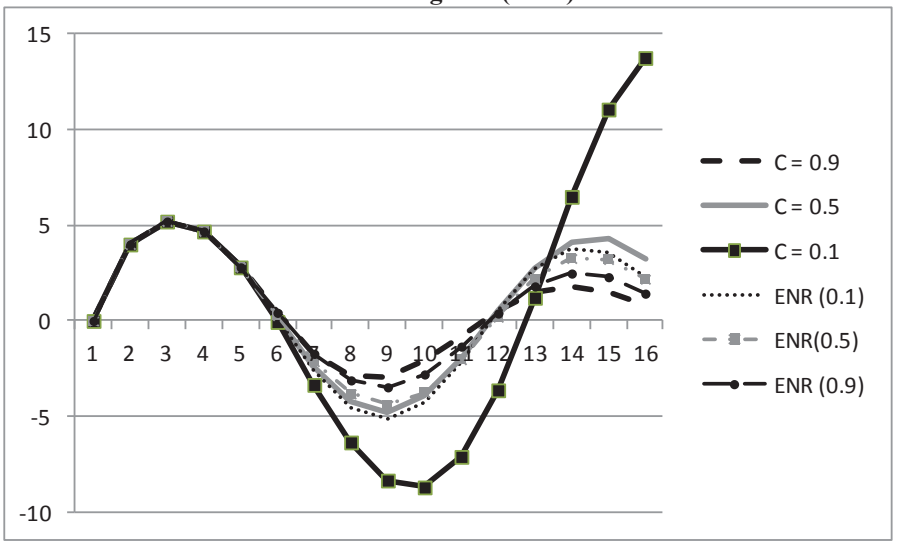
Graph 2 – Output gap's trajectory with Endogenous and Nonlinear Regimes (ENR)



Source: own elaboration.

The **Graph 3**, in its turn, presents together all the regimes that have been simulated and put into the Graphs 1 and 2.

Graph 3 – Output gap's trajectory with constant credibility degrees and with Endogenous and Nonlinear Regimes (ENR)



Source: own elaboration.

The output dynamics under the constant credibility degree C = 0.9 has the lower volatility among all the regimes simulated, but this is not what occurs in the authorities' monetary policy practice, that is, the Central

Bank's credibility cannot be considered as a constant in the real world; by the contrary, it is affected by the observed gaps and deviations, thereby influencing the agents' expectations and the monetary policy efficiency.

The ENR (0.9) has higher volatility in the output dynamics, in comparison with the constant credibility regime C = 0.9. It is verified because in the first one there is a credibility change process, as the monetary policy impulse is followed by output and inflation responses. At the first moment, the monetary policy impulse and the inflation rate responses cause a credibility degree loss, so that the output dynamics is more volatile under the ENR (0.9) than under the constant credibility regime C = 0.9.

The same finding occur if the ENR (0.1) is compared with the constant credibility regime C = 0.1, and if the ENR (0.5) is compared with the constant credibility regime C = 0.5. Therefore, the credibility degree losses (or gains), as a consequence of changes in the inflation rate, make the Endogenous and Nonlinear Regimes (0.1; 0.5; 0.9) more volatile than their respective constant credibility cases (C = 0.1; C = 0.5; C = 0.9).

5. Concluding remarks

Even if the countries are faced with the same kind of shocks and if they are also under the same type of policy regime, it is possible to verify differences in the economic dynamics among them. This work exploits some sources for these differences, which are basically related to the practice of central banking:

a) Central banks with lower (higher) credibility degree are constrained (improved) by inflationary dynamics which is more (less) sensible to the past inflation levels, that is, in such a case there is more (less) inertia in the inflationary process;

b) When central banks have low (high) credibility degree, its power to accommodate supply shocks or to stimulate output, and maintain or increase employment level, is constrained (improved);

c) The initial credibility degree is an important factor in determining economic variables dynamics. It means that the Central Banks' historic performance explains at least part of the differences of economic cycles that are observed in their respective economies.

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